RANKINE CYCLE GENERATION OF ELECTRICITY

Related Application

This application is related to copending U.S. Patent Application Serial No. 09/867,196, filed May 29, 2001 and entitled CONVERSION OF SOLAR ENERGY, the contents of which are incorporated herein by reference.

FIELD OF INVENTION

The present invention relates generally to the generation of electricity and more particularly to: (a) solar generation of electricity in combination with Rankine cycle generation of electricity; and (b) use of a Rankine cycle mechanism to generate electricity or do other work.

BACKGROUND

Solar energy is freely and daily available. It is a clean, non-polluting source of energy. Providing a reliable, long term, cost effective, efficient way of using sunlight to obtain electrical and thermal power has long been an unsolved problem, until the present invention.

It has been proposed that flat panel solar converters be used to convert direct sunlight into thermal or electrical energy.

Pedestal supported flat panels using direct sunlight to generate electricity were part of the Solar One project.

A circular, but concave reflector mounted on a single column or pedestal has been proposed. This approach was used on the Soleras water desalination project in Saudi Arabia and on the Solar Two project in Dagget, California.

Fixed position concave reflectors placed in an array and positioned in side by side rows on an incline have ben proposed. See U.S. Patent No. 4,202,322. Such an installation was made at the Federal Correctional Institution at Phoenix, Arizona.

Tiltable elongated concave reflector assemblies have been utilized, such as the one at Barstow, California, owned by FPL Energy SEGS VIII and IX.

Solar Systems comprising bidirectionally controlled Fresnel lens and solar cell assemblies, utilizing direct sunlight, have been proposed. See, U.S. Patent No. 4,649,899, for example. Also see, U.S. Patent No. 4,245,153. Optical detectors for dual axis tracking of the sun are known.

The above-identified proposals and installations have failed to provide reliable, low cost, efficient, variable capacity systems by which solar energy is converted to electrical energy. A long felt need has existed for solar energy conversion plants which are reliable, efficient, cost effective and size variable to meet both low and high capacity demands for thermal and electrical energy.

Further, the prior art has failed to maximize production of electricity from a solar generator by not using effluent coolant (by which the temperature of the solar generator is controlled) as a secondary source for producing additional electricity. Also, the prior art fails to meaningfully identify a commercial way by which a heated coolant, having only a moderately elevated temperature, can be used to cost effectively produce electricity or do other work.

Heretofore, the Rankine cycle principle has been applied to convert thermal energy into mechanical energy into electricity only in very expensive complex plants comprising steam driven turbines typically operating within a temperature range of 850° F to 1100° F, under high pressure. Fossil fuels are used to drive boilers which produce the high temperature, high pressure steam.

1. A method of using solar energy to generate primary and secondary electricity comprising the acts of:

directly converting solar energy to electricity at a solar electric generator;

cooling the solar electric generator with a coolant;

utilizing heat carried away from the electric generator by the coolant to drive a Rankine cycle generating system to also produce electricity.

2. A method according to Claim 1 wherein the coolant is a liquid and wherein the utilizing act comprises passing the heated coolant as a liquid through a heat exchanger to elevate the temperature of gas being passed through the heat exchanger which drives a Rankine cycle mechanism to produce torque which in turn drives an electricity producing-generator.

3. A method according to Claim 2 wherein the gas comprises steam.

4. A method according to Claim 1 wherein the electricity produced by the directly converting act is direct current electricity.

5. A method according to Claim 4 further comprising the act of converting the direct current electricity to alternating current electricity.

6. A method according to Claim 2 wherein the liquid coolant is recirculated through the solar electric generator and the heat exchanger.

7. A method according to Claim 2 wherein the gas is cooled and thereafter recirculated through the heat exchanger.

8. A method according to Claim 2 wherein the gas is displaced through a cooling device after passing through the Rankine cycle mechanism and before being returned to the heat exchanger.

9. A method according to Claim 2 wherein the liquid coolant discharged from the solar generator has a relative low temperature range below the vapor point and the gas is within a temperature range of 80° F or less.

10. A method according to Claim 2 wherein the gas is displaced into the Rankine cycle mechanism at a pressure on the order of 15 psi.

11. A method of using liquid at a moderately elevated temperature to do work comprising the acts of:

displacing liquid at an elevated temperature, below its vapor temperature through a liquid-gas heat exchanger;

displacing a gas through the liquid-gas heat exchange to transfer heat from the liquid to the gas;

displacing the gas to rotate a Rankine cycle lobe-displacement mechanism to create rotation of at least one output shaft;

converting the output shaft rotation to work.

12. A method according to Claim 11 further comprising the act of recirculating the gas through the heat exchanger and the Rankine cycle mechanism.

13. A method according to Claim 11 wherein the third displacing act comprises rotating two output shafts and the converting act comprises work derived from the rotation of two shafts.

14. A method according to Claim 13 wherein the two output shafts are geared together for common though opposite rotation.

15. A method according to Claim 12 further comprising the act of cooling the gas after it leaves the Rankine cycle mechanism and before it returns to the heat exchanger.

16. A method according to Claim 11 wherein the converting act comprises driving an electric generator via shaft rotation to obtain electricity.

17. A method of generating electricity by displacing a fluid at a moderately elevated temperature comprising the acts of:

introducing the fluid at a temperature within a range of up to 100° F and at an influent pressure within a range on the order of 15 psi into a space between oppositely rotatable lobes respectively mounted on interconnected shafts within a Rankine cycle mechanism;

applying the pressure of the fluid: (a) first predominantly against one lobe to forcibly rotate that lobe in a first direction causing the other lobe, through the interconnected shafts, to oppositely rotate in a second direction and (b) second predominantly against the other lobe to forcibly rotate the other lobe in the second direction causing the one lobe, through the interconnected shafts, to rotate in the first direction;

driving an electric generator with one or both shafts to create electricity.

18. A method according to Claim 17 wherein the fluid is a gas.

19. A method according to Claim 18 wherein the gas comprises steam.

20. A method of generating electricity comprising the acts of:

impinging influent fluid under low pressure and at a moderately elevated temperature on a continuous flow basis against a first shaft-mounted lobe of a Rankine cycle mechanism to forcibly rotate the first lobe and the shaft upon which the first lobe is mounted in a first direction, a second shaft-mounted lobe being caused to oppositely rotate in a second direction as a follower;

thereafter impinging the continuous flow influent fluid against the second lobe to forcibly rotate the second lobe and the shaft upon which the second lobe is mounted, the first lobe and the shaft upon which the first lobe is mounted to rotate in the first direction as a follower;

generating electricity via shaft rotation derived from the Rankine cycle mechanism.

21. A method according to Claim 20 further comprising the act of elevating the temperature of the fluid in a heat exchanger using a liquid at a temperature below its boiling point.

22. A method of generating electricity using a Rankine cycle mechanism comprising the acts of:

impinging influent fluid having an elevated temperature first against one lobe and then another lobe to rotate the lobes in opposite directions and to turn at least one output shaft;

using the rotation of the at least one output shaft to drive a generator by which electricity is produced.

23. A system for using solar energy to co-generate primary and secondary electricity comprising the acts of:

a solar generator which directly converts solar energy to electricity;

a cooling unit for cooling the solar electric generator with a coolant;

a Rankine cycle mechanism which utilizes heat derived from the coolant to drive a generator to also produce electricity.

24. A system according to Claim 23 wherein the coolant comprises a liquid, the cooling unit comprises a heat exchanger by which the elevated temperature of the liquid coolant increases the temperature of a gas being passed through the heat exchanger, and the Rankine cycle mechanism comprises at least one output shaft the rotation of which drives the generator.

25. A system according to Claim 24 wherein the gas comprises steam.

26. A system according to Claim 23 wherein the electricity produced by the solar generator is direct current electricity.

27. A method according to Claim 26 further comprising a direct current-to-alternating current converter by which the direct current electricity is transformed to alternating current electricity.

28. A method according to Claim 24 wherein the cooling unit comprises a recirculator by which liquid coolant is continuously recirculated through the solar electric generator and the heat exchanger.

29. A system according to Claim 24 wherein the cooling unit comprises a recirculator by which the gas is continuously recirculated through the heat exchanger and the Rankine cycle mechanism.

30. A system according to Claim 29 wherein the cooling unit further comprises a second heat exchanger whereby the gas is continuously displaced through the second heat exchanger after passing through the Rankine cycle mechanism and before being returned to the first heat exchanger.

31. A system according to Claim 24 wherein the liquid coolant discharged from the solar generator has a relative low temperature range below its vapor temperature and the gas is within the temperature range below the temperature of the liquid coolant.

32. A system according to Claim 24 wherein the gas is displaced into the Rankine cycle mechanism at a pressure of on the order of 15 psi.

33. A system for using liquid at a moderately elevated temperature to do work comprising:

liquid-gas heat exchange through which a liquid at an elevated temperature below its vapor point is displaced and through which a gas is displaced to transfer heat from the liquid to the gas;

a Rankine cycle lobe-displacement mechanism using the gas passed therethrough, after discharge from the heat exchanger, to rotate at least one output shaft;

a device driven by the shaft rotation to do work.

34. A system according to Claim 33 further comprising a pump by which wherein the gas is recirculated through the Rankine cycle mechanism and the heat exchanger.

35. A system according to Claim 34 further comprising a gas cooler for cooling the gas after it leaves the Rankine cycle mechanism and before it returns to the heat exchanger.

36. A system according to Claim 33 wherein the Rankine cycle mechanism comprises two oppositely rotated output shafts both of which drive the work device.

37. A system according to Claim 36 wherein the Rankine cycle mechanism comprises two interconnected shaft-mounted, oppositely rotating gears non-rotatably respectively connected to two output shafts for common though opposite rotation.

38. A system according to Claim 33 wherein the work device comprises an electric generator turned by rotation of the at least one shaft to obtain electricity.

39. A system for generating electricity by displacing a fluid at a moderately elevated temperature comprising the acts of:

a Rankine cycle mechanism into which the fluid is introduced at a temperature within a range on the order of 100 ° F or less and at a pressure within a range of on the order of 15 psi into a space between oppositely rotatable lobes respectively mounted on interconnected shafts of the Rankine cycle mechanism;

such that the pressure of the fluid is: (a) first applied against one lobe to forcibly rotate that lobe in a first direction causing the other lobe, through the interconnected shafts, to oppositely rotate in a second direction and (b) then is applied against the other lobe to forcibly rotate the other lobe in the second direction causing the one lobe, through the interconnected shafts, to rotate in the first direction;

an electric generator connected to one or both shafts to create electricity.

40. A system according to Claim 39 wherein the fluid is a gas.

41. A system according to Claim 40 wherein the gas comprises steam.

42. A system for generating electricity comprising:

a Rankine cycle mechanism which receives influent fluid under low pressure and a moderately elevated temperature on a continuous flow basis such that the fluid: (a) first against a first shaft-mounted lobe of the Rankine cycle mechanism to forcibly rotate the first lobe and the shaft upon which the first lobe is mounted in a first direction, a second lobe shaft-mounted being caused by said rotation of the first lobe to oppositely rotate in a second direction as a follower and (b) thereafter against the second lobe to forcibly rotate the second lobe and the shaft upon which the second lobe is mounted, the first lobe and the shaft upon which the first lobe is mounted being caused by said rotation of the second lobe to rotate in the first direction as a follower;

an electric generator connected to one or both shafts to generate electricity due to shaft rotation.

43. A system according to Claim 42 further comprising a heat exchanger by which the temperature of the fluid is elevated using a liquid at a temperature below its boiling point before introduction into the Rankine cycle mechanism.

44. A system for generating electricity comprising a Rankine cycle mechanism comprising interconnected oppositely rotating shaft mounted lobes such that influent fluid having an elevated temperature is impinged first against one lobe and then the other lobe to concurrently rotate the lobes in opposite directions to turn the shafts and a generator rotated by one or both output shafts to drive the generator to create electricity.